Weatherwise

The Tornado and Severe Storm Project

Inside a Texas Tornado

A Remarkable December Hailstorm

Air Weather Service Support to the Korean Effort

Meteorology in California Civil Defense

Vol. 4, No. 3, June, 1951

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE" — BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

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THE HAILSTORM PROBLEM

A GROUP of weathermen in the Denver area have for the past two years been co-operating in an attack on a serious local meteorological problem. The incidence of hail is very high in the area to the lee of the Rocky Mountains. Every summer sees much destruction to life and property from these storms whose origin and paths are not thoroughly understood.

Hail is particularly destructive to aircraft (see the front cover). It was under the leadership of Henry Harrison, manager of weather service for United Air Lines, that the current study was undertaken three years ago. Mr. Harrison secured the co-operation of all Weather Bureau officials in the Denver area as well as of many fellow employees. Each observer uses his home as his observation point, and this gives a rather good coverage of the city of Denver and environs. From 12 reporting points in 1949, the network grew to 38 in 1950; about the same number will comprise the 1951 network.

Hail frequency has been below normal for the past two years. Nevertheless, two severe storms occurred in 1950. On June 16th every section of the city experienced a fall of hail, and many sections had four hailstone visitations. Some stones reached the size of golf balls. On September 16th, another severe storm cut a path two miles wide and 40 miles long across the area, with 1¼-inch stones reported.

This community observing program of local weathermen should serve as a model for other communities that have comparable weather problems.

The front-cover picture attests the seriousness of hail damage to aircraft. Fortunately, this plane was on the ground at the time. The storm causing the damage is reported to have climaxed 25 successive days of rain. A foot of hail fell on Pueblo, Colorado, breaking more than 10,000 windows and damaging 2,000 roofs.

The highest hail-thunderstorm ratio in the country is found over the western Great

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Cover: Damage to a plane owned by James Ronco during a hailstorm at the Pueblo, Colorado, airport in July, 1950. Acme photo.

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A tornado at Manhattan, Kansas, May 31, 1949. USWB photograph, by H. E. Dale.

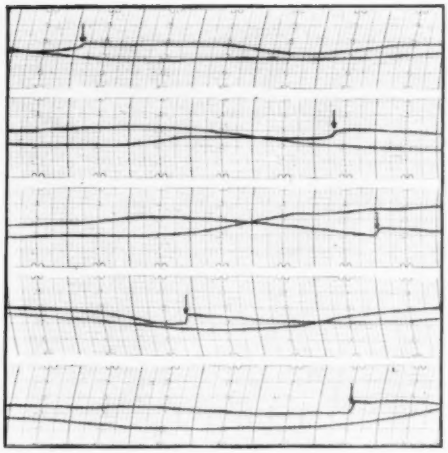
The Tornado and Severe Storm Project

MORRIS TEPPER, UNITED STATES WEATHER BUREAU

SPRING is the season of reawakening in the realm of nature. From the Southland many migrants in the animal and physical world move northward in the congenial companionship of currents of warm tropical air. Among these seasonal travelers is a natural phenomenon of terrible proportions — the tornado.

During the cold months the tornado is largely dormant, with the area of maximum occurrence confined to the states adjacent to the Gulf of Mexico. In March the real tornado season commences, and the scene of greatest activity shifts into northern Mississippi and Alabama. By April the center of action has expanded and moved westward into the lower Plains states. May witnesses the zenith of tornado occurrences, with further expansion of the tornado area to the north. A long finger of distinct frequency extends from Oklahoma to the southern border of Minnesota, and this situation carries over into June. Thus, the height of the tornado season occurs in an area of rich farmland interspersed with small urban areas. Tornadoes in this area, therefore, seldom go unnoticed by human eye, and observational conditions should be at the optimum.

The tornado as a physical spectacle has long fascinated the scientist, yet has steadfastly defied the research meteorologist who wished to bring it under concentrated study. This was largely due to the difficulty of reducing the tornado phenomenon to laboratory dimensions, where conditions could be controlled and the dynamics of the vortex observed under close study. Furthermore, until recently the habitat of the tornado in the upper air was an unexplored land to the weatherman. During the past two decades, the situation has been greatly improved with the introduction of electronic upper-air sounding



Five examples of pressure jumps as recorded on accelerated microbarographs. The time interval between major divisions of the sheet is one hour.

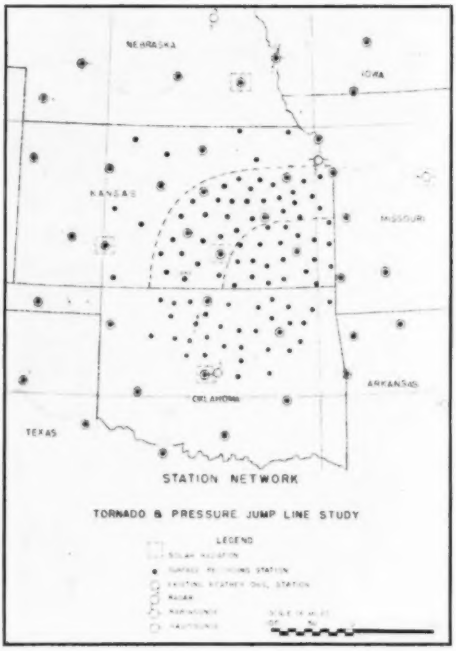
devices, such as the radiosonde and rawinsonde, so that the development of tornado conditions aloft can be more easily evaluated.

It is obvious that to study a subject so unusual in occurrence and so small in size as the tornado requires a different observational approach than that for ordinary synoptic meteorology. For plotting the regular movement of air masses and frontal systems, a network of stations spaced 50 to 100 miles apart is considered adequate. For tornadoes, however, a much closer network is needed, and for this the Weather Bureau has recently organized the Tornado and Severe Storm Research Project, with its present activity centered in the Kansas-Oklahoma area of maximum May-June tornado occurrences.

One of the mainsprings of the present activities of the Tornado Project is the author's hypothesis that the occurrence of a tornado vortex in the atmosphere is associated with a meteorological phenomenon known as the pressure jump. A pressure jump can be loosely defined as a sudden rise in barometric pressure as recorded on the trace of a microbarograph. The intersection of two such pressure-jump lines of unequal intensity moving from different directions forms a contact discontinuity in their zone of interaction. This discontinuity is characterized by a sharp wind shear, and it is this unstable wind condition that generates the vortices which under suitable thermodynamic conditions develop into tornadoes.

To pinpoint the pressure-jump lines, the Tornado Project has established a primary network of about 135 stations. Many of these are maintained by regular co-operative observers of the Weather Bureau who have years of experience in routine weather observations, but others are new and have been established in the homes of persons willing to assist. The main network is called "the arc," as it runs in concave fashion from near Kansas City on the northeast to the town of Anthony, Kansas, on the Oklahoma border to the southwest.

The basic instrument in the study is a modified Friez microbarograph. The recording mechanism has been speeded up so that two complete revolutions in one day are made. This open-scale feature permits the resolution of pressure data to a period of one minute in time, thus permitting a fine microscopic view of the atmospheric pressure fluctuations. This



The stations utilized in the Tornado Project network. Those within the dashed lines in Kansas are each fully complemented with an accelerated microbarograph, wind recorder, hygrothermograph, and recording rain gage.

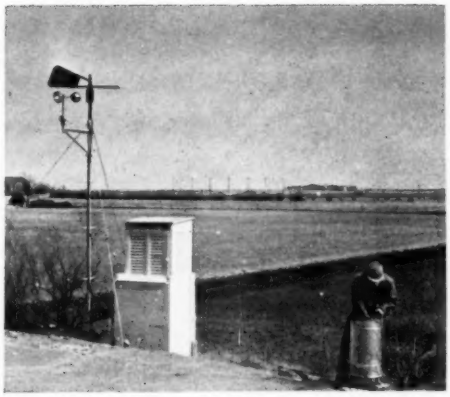
modification was previously employed in the Thunderstorm Project, which set the observational pattern for the present survey.

Also located in "the arc" are 30 complete weather stations equipped to record all the major elements. They have high-speed recording rain gages, hygrothermographs, and recording wind speed and direction equipment, in addition to the stepped-up microbarographs. The entire survey network is in charge of Dansy T. Williams, with field headquarters at Kansas City, Missouri.

As a supplement to the observations in "the arc," weather observers and the general public have been asked to report all tornado occurrences to the Section Director, Weather Bureau Office, Topeka, Kansas. Information as to the date, time, approximate length and width of the tornado's path, direction, speed, description of the funnel, concurrent storminess, and attendant destruction, is desired. These reports will then be forwarded to the Tornado Project headquarters at Kansas City. Members of the Amateur Weathermen of America in this area are requested to collect and forward all material on tornado occurrences in their neighborhood.

In addition to the close surveillance on the ground, special upper-air soundings are being made for the project at Omaha and North Platte, Nebraska, Oklahoma City, Oklahoma, Columbia, Missouri, Dodge City, Kansas, and Little Rock, Arkansas. The soundings are timed to gather as much data as possible on the upper-air structure during conditions that foster and attend the development of squall lines and tornadoes. J. R. Lloyd, the official in charge of the Kansas City office who has long been a student of tornadoes, is scheduling flights to coincide with periods of actual or expected severe storm activities. Similar data is being obtained with the U. S. Air Force rawinsonde stations at Sherman Air Force Base, Ft. Leavenworth, Kansas. Plans have also been formulated for the dispatch of Air Weather Service mobile weather units to the area when such units can be made available.

Radar coverage is being provided by the Weather Bureau station at Norfolk, Nebraska, as well as by the Air Weather Service installation at Offutt Air Force Base, Omaha, Nebraska, Sherman Air Force Base, Kansas, Vance and Tinker Air Force Bases in Oklahoma. Photographs of each radar scope are being made continuously during squall or tornado conditions.



A complete station installation at Hillsboro, Kansas, showing the wind mast with vane and anemometer, recording rain gage, and instrument shelter. The upper portion of the shelter contains a hygrothermograph; the lower holds the wind recorder and microbarograph. USWB photograph, by Walter H. Hoecker.

The data gathered in the many methods described above will be utilized in three ways:

1. The Weather Bureau forecasting center at Kansas City will attempt to forecast on the basis of current conditions the possibility of the occurrence of a tornado or severe storm. The primary tool used by this group is the Fawbush-Miller method of forecasting tornadoes (described elsewhere in this issue).

2. A unit of the Short Range Forecast Development Section, Scientific Services, U. S. Weather Bureau, Washington, D. C., will investigate the large-scale features attending tornadoes and will formulate their synoptic criteria.

3. A unit of the Meteorological Physics Section, Scientific Services, will study the small-scale features of the storms and will probe the mechanisms that produce them.

Unfortunately for meteorological knowledge, the setting up of the Tornado Project system seems to have provided the people of Kansas with the best tornado insurance they have ever had. For at the present writing there have been no tornadoes in "the arc" during 1951.

Inside a Texas Tornado

ROY S. HALL, CAPTAIN, U. S. ARMY, RETIRED

THAT warm morning of May 3, 1948, my wife and I were sitting in our back yard making small talk, when suddenly she pointed upward and said, "Look how still those leaves are."

I was startled. The wind was blowing from the south at about 25 miles an hour, and there could be no reason in such a remark. But when I looked up at the big hackberry tree I saw what she meant. The wind was so steady and dead-level in its pressure that leaves and small branches were pushed before it and held almost motionless, with scarcely a tremor.

"I'm going in," my wife said. "That solid pressure scares me."

After a bit I went in to have a short rest on my cot. I was barely stretched out when a hard clap of thunder brought my feet to the floor with a slam. The ominous silence which follows close thunder got on my nerves, and I walked through the house to the west lawn to have a look at the weather.

Since noon, thunderstorms had been developing to the west and southwest, muttering and grumbling, miles away, but as the three small clouds that showed prospects of rain were 15 miles off, and drifting north on the air current, I had given them no more thought. The temperature was in the middle 80's, and the air was very humid.

When I stepped off the front porch one of those little thunderheads almost hit me in the pit of the stomach. It wasn't little any more, but spanned the western sky, black as ink, less than three miles away. And right across its nearer rim, low, very low, a mile-long scud-cloud was sliding along. It was moving swiftly eastward, and the whole cloud had done something I had never heard of before. It had made a right-angle turn in the sky and was cutting across the wind current, which definitely had not slackened. I went to the porch and yelled for my wife.

Back on the lawn I did not know she had come out, till she spoke and scared me. "You sounded urgent, so I hurried the children out . . . Oh!" She had seen the storm for the first time. "What a terrible cloud!" I looked around and saw our four children standing on the porch. She said nothing further for the moment, but I felt her hand touch my arm in a muted question.

The squall, which was now about two miles away, was coming directly toward us, and the scud-cloud, stretched across its front between 400 and 500 feet above the earth, was revolving as if it were being pushed in reverse along the ground. Behind the scud-cloud a curtain of dark, green rain was falling in a solid, opaque wall.

The south wind was veering. In a matter of a few seconds it had changed, and was blowing, undiminished, from the southeast toward the cloud. Lightning, the most fearful I have ever seen, and wide as a house, flashed with some regularity between the scud-cloud and the ground.

In the comparative stillness following the terrific thunder crashes I could hear a sustained hollow roaring, like a distant freight train. Feeling my wife's eyes on my face, I said, "Sounds like heavy hail." But it wasn't hail. She knew it wasn't, and I did too. While the sound was somewhat similar, there was a vast difference. You can't feel the sound of hail vibrating the air against your ear drums, nor pulsating it against your face. This was a new sound, one we had never heard before.

The low, deadly looking scud-cloud was right on us now, and I could see no sign of a tornado funnel this side of the greenish rain. But it was there, and my wife knew it was there. I told her to go in and take the children. We had no storm cellar, but, had there been a tornado showing, we could have gotten into the car and run out of its path. Now, we had to take a chance on it missing

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ED. NOTE: Except to shorten some less important details, no attempt has been made to edit this eye-witness account to obtain more complete consistency and agreement with general meteorological theory. The tornado struck the community of McKinney, Texas, where Captain Hall has devoted much of his time to meteorology as a hobby. This is a unique instance of a trained weather observer looking into the vortex of a tornado.

The author's house after the tornado, looking northwest. The building was moved off its foundations. Captain Hall comments: "Although the tornado set me back financially, I would not trade what I saw for the house and furniture back again."

us. It was behind the rain, without question; I had seen them that way.

In another minute the low cloud passed close overhead, and the dusk of early evening enveloped us. I turned to go in, and as I went up the porch steps hailstones the size of tennis balls began falling on the house and in the yard. These made my heart sink, for they almost invariably fall in the forefront of a tornado. They came down sparsely, one on about each square yard, but they made a most hideous bang and clatter, and I knew some of them were going all the way through our shingled roof. We all went into the west bedroom.

Lightning was striking all around the house now, adding its horror to the fast-rising din. As my wife snapped on the overhead light, a gust of wind and rain hit the west wall of the room with a crash. My wife was pointing to the west wall. "The wall's blown in!" She had to scream to make herself heard. I could see that it had slipped inward six inches or more at the ceiling, and was vibrating under the wind pressure. Drops of water were hitting my face across the room. I tried to assure her. "That gust always comes ahead of a rainsquall," I shouted.

But there was no abatement in the deafening hubbub outside. I knew it was growing in intensity by the second, and realized that a tornado was right on us. I yelled in my wife's ear:

"Everybody in the back room! Get under the bed!"

Under a foolish impulse I jumped to the south window for a last look outside before following the family. As I did so the overhead light went off (3:04 p.m., as shown later by our electric clock). Between the flashes of lightning it was as dark as midnight, but by shielding my eyes I could see somewhat. I saw that my neighbor's house across the vacant lot was standing, but trees and shrubbery out that way were flattened almost to the ground. From the course the planks, sheet-iron, and other debris took as they flailed over the lot, I saw that the wind was from due west. It was a grim perspective, but out of it all I gathered a bit of hope.

The wind was from the west! It should

have been from the south. While a tornado, as a whole, moves generally eastward, the funnel itself rotates counterclockwise, and the west wind indicated that we were in the southern edge of the twister. It, apparently, was passing just north of us. And too, the vivid lightning and rending crashes were passing on, and there was now a decided lull in the screeching roar outside.

And then very suddenly, when I was in the middle of the room, there was no noise of any kind. It had ceased exactly as if hands had been placed over my ears, cutting off all sound, except for the extraordinary hard pulse beats in my ears and head, a sensation I had never experienced before in my life. But I could still feel the house tremble and shake under the impact of the wind. A little confused, I started over to look out the north door, when I saw it was growing lighter in the room.

The light, though, was so unnatural in appearance that I held the thought for a moment that the house was on fire. The illumination had a peculiar bluish tinge, but I could see plainly. I saw the window curtains lying flat against the ceiling, and saw loose papers and magazines packed in a big wad over the front door. Others were circling about the room, some on the floor and others off it. I came out of my bewilderment enough to make a break for the back of the house.

But I never made it. There came a tremendous jar, the floor slid viciously under my feet, and I was almost thrown down. My hat, which I had not removed, was yanked off my head, and all around objects flashed upward. I sensed that the roof of the house was gone.

As I gained footing another jarring wham caught me, and I found myself on my back over in the fireplace, and the west wall of the room right down on top of me. The "whams" were just that. Instead of being blown inward with a rending crash of timbers, as one would expect of a cyclonic wind, the side of the room came in as if driven by one mighty blow of a gigantic sledge hammer. One moment the wall stood. The next it had been demolished. The destruction had been so instantaneous that I retained no memory of its progress. I was standing, and then I was down, 10 feet away. What happened between, I failed to grasp or to sense.

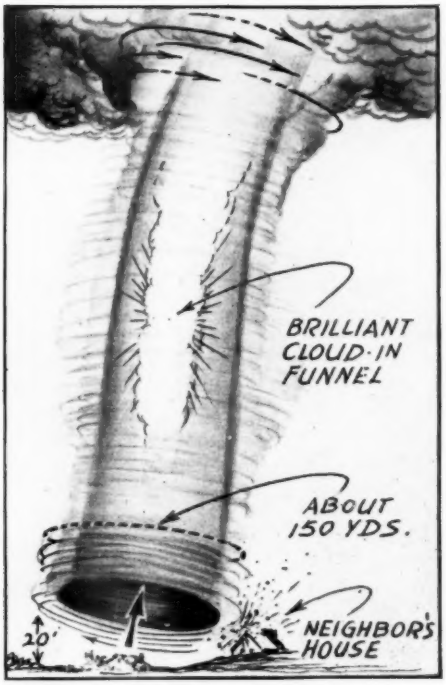
By a quirk of fate I was not seriously injured, and as soon as I had my senses about me I clawed up through the wreckage, and crawled around and through the hole where the east door had been. I could tell by the bluish-white light that the roof and ceiling of this room were gone also. I almost ran over my four-year-old daughter, who was coming to see about me. Grabbing her up, I was instantly thrown down on my side by a quick side-shift of the floor. I placed her face down, and leaned above her as a protection against flying debris and falling walls.

I knew the house had been lifted from its foundation, and feared it was being carried through the air. Sitting, facing southward, I saw the wall of the room bulge outward and go down. I saw it go, and felt the shock, but still there was no sound. Somehow, I could not collect my senses enough to crawl to the small, stout back room, six feet away, and sat waiting for another of those pile-driver blasts to sweep the rest of the house away.

After a moment or so of this, I became conscious that I was looking at my neighbor's house, standing unharmed 100 feet to the south. Beyond I could see others, apparently intact. But above all this, I sensed a vast relief when I saw that we were still on the ground. The house had been jammed back against trees on the east and south and had stopped, partly off its foundation.

The period of relief I experienced, however, was a very short one. Sixty feet south of our house something had billowed down from above, and stood fairly motionless, save a slow up-and-down pulsation. It presented a curved face, with the *concave* part toward me, with a bottom rim that was almost level, and was not moving either toward or away from our house. I was too dumbfounded for a second, even to try to fathom its nature, and then it burst on my rather befuddled brain with a paralyzing shock. It was the lower end of the tornado funnel! I was looking at its inside, and we were, at the moment, within the tornado itself!

The bottom of the rim was about 20 feet off the ground, and had doubtless a few moments before destroyed our house as it passed. The interior of the funnel was hollow; the rim itself appearing to be not over 10 feet in thickness and, owing possibly to the light within the funnel, appeared perfectly opaque. Its



From a sketch by the author, Eric Sloane made this drawing of the tornado funnel, considered transparent for illustration purposes, and shown as if the observer had been off to one side instead of beneath it.

inside was so slick and even that it resembled the interior of a glazed standpipe. The rim had another motion which I was, for a moment, too dazzled to grasp. Presently I did. The whole thing was rotating, shooting past from right to left with incredible velocity.

I lay back on my left elbow, to afford the baby better protection, and looked up. It is possible that in that upward glance my stricken eyes beheld something few have ever seen before and lived to tell about. I was looking far up the interior of a great tornado funnel! It extended upward for over a thousand feet, and was swaying gently, and bending slowly toward the southeast. Down at the bottom, judging from the circle in front of me, the funnel was about 150 yards across. Higher up it was larger, and seemed to be partly filled with a bright cloud, which shimmered like a fluorescent light. This brilliant cloud was in the middle of the funnel, not touching the sides, as I recall having seen the walls extending on up outside the cloud.

Up there too, where I could observe both the front and back of the funnel, the terrific whirling could be plainly seen. As the upper portion of the huge pipe swayed over, another phenomenon took place. It looked as if the whole column were composed of rings or layers, and when a higher ring moved on toward the southeast, the ring immediately below slipped over to get back under it. This rippling motion continued on down toward the lower tip.

If there was any debris in the wall of the funnel it was whirling so fast I could not see it. And if there was a vacuum inside the funnel, as is commonly believed, I was not aware of it. I do not recall having any difficulty in breathing, nor did I see any debris rushing up under the rim of the tornado, as there surely would have been had there been a vacuum. I am positive that the shell of the twister was not composed of wreckage, dirt or other debris. Air, it must have been, thrown out into a hollow tube by centrifugal force. But if this is true, why was there no vacuum, and why was the wall opaque?

When the wave-like motion reached the lower tip, the far edge of the funnel was forced downward and jerked toward the southeast. This edge, in passing, touched the roof of my neighbor's house and flicked the building away like a flash of light. Where, an instant before, had stood a recently constructed home, now remained one small room with no roof. The house, as a whole, did not resist the tornado for the fractional part of a second. When the funnel touched it, the building dissolved, the various parts shooting off to the left like sparks from an emery wheel.

During pistol practice in the army, when the light was favorable, I have seen bullets from a .45 pistol flash from gun to target. The bullets had a known velocity of 825 feet a second. The white planks from the house moved at a speed equal to, if not greater than, those of the bullets, which would establish the velocity of the tornado's rotation close to 600 miles an hour. This, I believe, is conservative. My own conviction is that the funnel was spinning faster than the speed of sound, account-

(Continued on page 65)

Groundfog forming from warm wind blowing across the deep hail that fell in St. Louis County, December 2, 1950. Photograph by David R. Wallin, courtesy of St. Louis *Post-Dispatch*.

A Remarkable December Hailstorm

EDWARD M. BROOKS, ST. LOUIS UNIVERSITY

HAILSTONES of unusual shape fell in St. Louis County during a remarkable early winter storm on December 2, 1950. Hail accumulated in some places in such depth as to delay traffic. The path of the hail extended across the Mississippi River northeastward to nearby Illinois, where several tornadoes were reported along the projected track of the Missouri hail. The disturbance occurred ahead of a cold front under a synoptic situation similar to another severe hailstorm a year before on December 11, 1949.

Both storms were witnessed by Edward E. Friton at his home in Webster Groves, Mo., and he succeeded in taking photographs of the stones as well as making close observations and accurate measurements. Friton has summarized his observations of the hailstones of December 2, 1950:

"Some of the stones measured as large as ¾ inch thick and 1-5/16 inches in diameter, and showed rudimentary star formation such as observed on December 11, 1949. Some stones were all cloudy, others had cloudy centers or center rings, whereas others (small ones, ⅜ to ½ inch in diameter) were glass clear throughout. Most stones ranged from oblate spheroids to fairly flat shapes. Some had radial rills going in toward their centers, with a central hole from one side, but not all the way through. The points on star-shaped stones were clear. Many stones had points all over one side of their peripheries, like quartz crystals found in hollow rock formations, but these were convex instead of concave. Hail depths were as much at 1½ inches in places, but the ground cover averaged about ¾ of an inch."

In Richmond Heights (6½ miles west of St. Louis), R. D. M. Clark found the largest stones to be 1¼ inches in diameter. These had an oblate layer of clear ice, a spherical

inside layer of rime ice, and a nucleus of clear ice. Even after six hours of melting, stones averaging ¾ inch were found. Hail estimated to trap one inch of water averaged four inches deep on level ground, but the torrential rain that occurred washed the hail down into small valleys where accumulations three feet deep clogged sewers, flooded and blocked roads. This wintry scene was created less than 10 minutes after the temperature had registered 70° F. A bulldozer was used to plow through the hail drifts, and workmen loaded the hail onto trucks by conveyor belts.

The heavy hail passed over Forest Park in St. Louis, crossed the river into Illinois, through Venice, Madison, Maryville, Troy, and Marine, Illinois. In Maryville and Troy, wind and heavy hail broke many south and west windows. In Troy, a stone picked up 45 minutes after the storm and saved in a refrigerator for 24 days measured at the end of that time 2¾ by 2¼ by 2 inches, and had about 50 nodules on its roughly round surface. When they fell, the stones were estimated to be as large as oranges.

According to Friton, the precipitation at Webster Groves began about 3:00 p.m. and lasted at least 20 minutes. The wind, which had been strong southwest, shifted to moderate west. Although considerable lightning was seen in the west earlier, none was noted very close even during the height of the storm. At first, light rain quickly turned to hard rain with what sounded like very small hail, but no pieces were seen. Hail then came with very hard rain, the hail becoming larger and falling in great quantity for about five or six minutes. The temperature dropped nearly 20° F., causing dense fog in some sections. Another strong rainstorm started at 4:45 p.m., but was of short duration, with some severe lightning.

On the same afternoon, three tornadoes occurred in nearby Illinois, one crossing the river about 60 miles above St. Louis and apparently not striking the ground. The second started just south of Fosterburg (devastated in a tornado on March 19, 1948), with a narrow ground path, then skipped all the way to Mt. Olive; it lifted a car off U. S. Highway 66, carrying it 600 feet, killing the motorist. The hail near these tornadoes was insignificant compared with that in St. Louis. But the thunderstorm six miles north of the tornado path in Fosterburg was fairly severe, a barn being struck by lightning and burned to the ground.

The third tornado caused severe damage in Greenville, Illinois, its path beginning at Highland about five miles south of the northeast end of the severe hailstorm path. From Highland it followed very close to U. S. Highway 40 and the Pennsylvania Railroad tracks all the way to Greenville.

Due to the cold weather in December, many houses were uninhabitable if they remained standing. Some of the occupants were hospitalized and two were killed.

The microbarograph trace at Overland, Missouri, showed a rapid pressure fall of 1½ millibars from 2:30 to 3:00 p.m., when a sudden rise of half a millibar occurred with the arrival of the squall line. At 4:30 p.m. the pressure started rising rapidly, with the arrival of the cold front. Thunderstorms occurred with both the squall line and the cold front.

The 9:00 a.m. CST sounding at Columbia, Missouri, showed winds of 30 to 50 knots from the southwest at all levels (except the very lowest 2,000 feet) up to at least 18,000 feet. The lower moist layer extending up to about 7,000 feet exhibited a conditionally unstable lapse rate and a dew point depression of two to four degrees centigrade. At the top of this layer the temperature rose abruptly from 6° to 8° C. through a thin inversion. The dew point dropped sharply (from 4° to −1° C.), and continued to drop almost as rapidly to −8° C. at about 9,000 feet, where the dew point depression was 14° C. Above this level, the lapse rate was very nearly dry adiabatic and the temperature reached 0° C. at about 11,000 feet. The dew point depression gradually decreased to only three degrees at about 15,000 feet, remaining at that value above this height.

The most significant feature of this sounding was the pronounced convective instability indicated by the moisture stratification between about 7,000 and 9,000 feet, the wet-bulb potential temperature decreasing 1½ degrees. This situation, combined with the steep lapse rates through the sounding, gave severe convective phenomena when the maritime tropical air was lifted at the prefrontal squall line.

Air Weather Service Support to the Korean Effort

WITHIN 48 hours after the North Korean hordes crossed the 38th parallel in their sudden invasion of South Korea last June, the first Air Weather Service detachment was airlifted from Japan to a landing strip at Taegu. Since then, units of the 2143d Air Weather Wing have been the primary source of the United Nations Command not only for weather observations and forecasts but also for climatological summaries, oceanographic studies and wave forecasts, special compilations of tide tables, astronomical tables, data on the freezing of waters in and about Korea, and other highly specialized information.

In this manner, weather has once again "gone to war." At the outset, the Air Weather Service had an established organization of 14 units scattered through Japan and Iwo Jima; its mission was to provide weather support for all Air Force and Army units in the Far East. By October, the organization had expanded considerably, with units located in the combat area of Korea and in Japan. Today, these squadrons and detachments, plus units of the RAF and Japanese and Korean native observation posts, feed a constant flow of vital weather data into the giant Tokyo Weather Central, which is the meteorological nerve center for the United Nations Command.

It is fortunate that these Air Weather Service units were on the scene and in a state of complete organization to do the job of weather evaluation, since weather has proved a true "friend or foe" from the very start of the Korean campaign.

Weather proved to be an ally of the aggressor ground forces in the beginning. The invasion of South Korea began during the summer monsoon season, which resulted in the worst flying weather of the year and neutralized our air superiority by grounding all air operations over the combat area. The heavy monsoon rains also aided the North Koreans by bogging down the more highly mechanized United Nations forces.

The prolonging of the campaign through the bitter winter months again found weather on the side of the North Koreans. The extreme cold effectively offset our bomber strikes against bridges inside enemy territory. The rivers quickly froze and permitted the enemy to cross water barriers with even greater ease than when the bridges were intact. By having their communication lines remain open, in spite of our air efforts, the enemy was able to sustain their major counter-attack.

The weather has served as a friend to the United Nations forces as well. Clearing skies, following the monsoons, allowed our fighters and bombers vigorously to attack the enemy rear areas, which materially assisted the UN ground forces in repelling the Communists at the Pusan perimeter. Again at Inchon, predictions of one of the highest tides of the year — about 32 feet above the datum for charts of the area — contributed to the success of the UN landings that ultimately broke the resistance of the Communists, leading to their retreat from South Korea.

It is not generally known that, while the weather finally worked for our success at Inchon, it almost wrecked the invasion plans. Just prior to the landings, a freakish Pacific typhoon, labeled "Kezia," moved out of its normal breeding waters to the south and approached the general area of Korea, seriously threatening the movement of landing craft. Heavy seas and high winds damaged the landing facilities at Wonsan and disrupted the minesweeping of the approach lanes into Inchon. Strong winds and cloud cover curtailed much of our air operations out of Japan, and much damage was suffered by the native population. Fortunately, the typhoon took a northeasterly path along the east coast of Japan, and finally dissipated itself in an area away from the combat zone.

The problems affecting a high efficiency in weather forecasting in Korea are immense. Since the entire mainland to the west of Korea is in hostile hands, we are deprived of much-needed weather observations from the area where Korean weather originates. Unlike the situation during World War II, we no longer receive reports from China and Siberia, and must now resort to other methods

to obtain observations for our forecasts.

Aerial reconnaissance has been the only practical substitute for ground observations. Within a few hours after hostilities started, the 56th Strategic Reconnaissance Squadron, Medium, Weather, based in Japan, sent a WB-29 weather observing mission over Korea. Since that day in June the squadron has flown at least one mission daily. Many times the observations available from these weather "reccie" flights have been the only source of weather information behind the enemy lines.

Along with the WB-29 missions, we now depend on an additional source of North Korean weather data through the use of "snoopers." These are qualified weather technicians, aboard bombers and strategic reconnaissance aircraft of the tactical air units that penetrate deep inside Communist territory, who radio back actual weather conditions encountered over the target area.

Additional weather reconnaissance is provided by several Air Weather Service officers who are pilots as well as forecasters and who lead a dual life of combat pilot and weather observer. Two of these pilot-forecasters, flying F-51 fighters on several recent sorties, were credited with the destruction of 10 tanks, 45 trucks, and numerous other vehicles.

This type of special aerial reconnaissance plus pilot reports, combined with actual observations made by highly mobile weather units which operate close behind the front lines, have resulted in an accuracy of over 70 per cent in operational forecasts. While all concerned would naturally prefer the efficiency to be higher, the extreme limitations under which these forecasts are made preclude much improvement at this time.

The support to UN combat units in Korea is providing the Air Weather Service with an unusual opportunity to preview its problems in the new jet age. Many of our newest, high-speed aircraft are committed to the Korean war. The problems these aircraft create, because of their extreme speed and altitude possibilities, are being studied and developed.

Tornado Forecasting Study

GENERAL weather map conditions present in a tornado situation have been the subject of a study project of the Air Weather Service research staff at Tinker Air Force Base, Oklahoma City, Okla. The main emphasis has been on forecasting not only the occurrences but the particular areas where a tornado visitation is likely.

This project was stimulated by the severe damage caused by two twisters that struck Tinker Air Force Base in one week during late March, 1948. The damage to aircraft and military installations was estimated at $16,000,000, the greatest tornado disaster in Oklahoma's history.

The progress of the work accomplished so far was presented recently at a meeting of the American Meteorological Society by the three officers engaged in the study: Lt. Col. E. J. Fawbush, Capt. R. C. Miller, and Capt. L. G. Starrett. Their results are published in the January, 1951, **Bulletin** of the society.

Tornadoes, they found, always develop with cumulonimbus activity, either of the line squall or the individual type. Along with a funnel-shaped cloud there may also be high windstorms of the non-revolving type. Limited areas of heavy hail have also been noted in such situations.

Topography plays a part in determining the area of maximum occurrence of the tornado. The primary maximum is about 600 miles east of the mean ridge of the Rocky Mountains, and a secondary maximum is about 100 miles east of the Appalachian ridge. Investigation has revealed no effect of small topographic features. Thus, the action of topography is an indirect one, occurring through modification of both large-scale air currents and air mass structure.

In the **Bulletin** article, it is stated that after a lengthy investigation of a large number of synoptic situations in the United States prior to 1949, it was found that tornado conditions developed when, and only when, the synoptic situation was characterized by the following conditions:

1. A layer of moist air near the earth's surface must be surmounted by a deep layer of dry air.

2. The horizontal moisture distribution within the moist layer must exhibit a distinct maximum along a relatively narrow band in the form of a moisture wedge or ridge.

3. The horizontal distribution of winds aloft must exhibit a maximum speed along a relatively narrow band at some level between 10,000 and 20,000 feet, with the maximum speed exceeding 35 knots.

4. The vertical projection of the axis of wind maximum must intersect the axis of the moisture ridge.

5. The temperature distribution of the air column as a whole must be such as to indicate conditional instability.

6. The moist layer must be subjected to appreciable lifting.

FORECASTING THE WEATHER

Forecasting the Duration of Low Clouds Following Cold Front Passages at Elkins, West Virginia

ROBERT A. HOOVER, USWB FORECAST CENTER
WASHINGTON NATIONAL AIRPORT

AN AIRPLANE PILOT who plans to make a flight westward from Washington, D. C., may telephone the Weather Bureau at Washington National Airport at any time — day or night — to inquire about the weather conditions which he might encounter

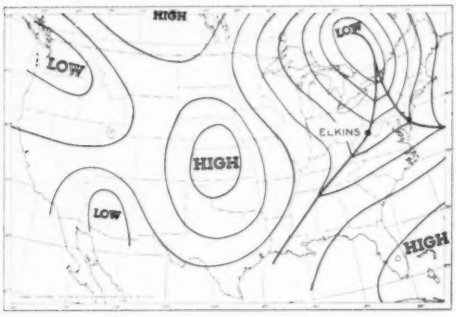


Fig. 1. A weather map showing a cold front passing Elkins, West Virginia, with northwesterly flow to the west of the cold front.

in flying over the Appalachian ridges in West Virginia. A problem which often confronts the forecaster is that of determining the duration of low cloudiness over the ridges following the passage of a cold front. Normally, over more level terrain, in an area not adjacent to a large body of water, one expects the passage of a cold front from the west to be followed shortly by clearing weather — not so over the Appalachian ridges in West Virginia. During the winter months it is not unusual for low clouds to remain over the ridges as much as 36 hours following the frontal passage.

The purpose of this investigation was to find some systematic indices of the duration of such low cloudiness. The station in the mountains which was selected for study was that at Elkins, West Virginia, and at the outset of the study all cases of cold front passages at Elkins during the months of January, February, and March, were examined for possible clues as to the duration of low cloudiness. It was recognized, of course, that such cloudiness was associated with the topography of the ground. In the case of northwest winds, the air behind the cold front would be forced to ascend during its journey from the vicinity of the Great Lakes to Elkins (Fig. 1).

Such an ascent must occur under these circumstances since, for example, the increase in elevation between Toledo, Ohio, and Elkins is 1,300 feet, and most of the ascent would be in the last 50 miles just before the air reached Elkins.

Of the many weather elements studied to find an index of the duration of the cloudiness, those incorporated in Fig. 2 were found to show the best relationship. This chart includes the orientation and number of 3-millibar isobars between Elkins and the center of the ridge of high pressure back of the cold

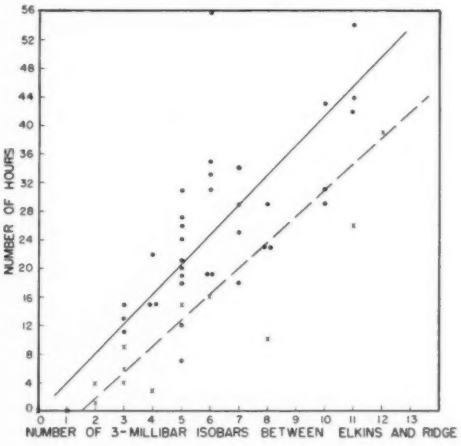


Fig. 2. The chart for forecasting the duration of low cloudiness (in hours beginning at time of front passage) during January and February when isobars behind the cold front indicate flow from the northwest. The solid line is for use when showers are present in Ohio or Indiana at the time the front passes Elkins; otherwise the dashed line is used.

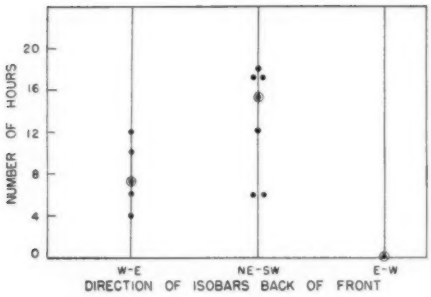


Fig. 3. The circled dots show the median duration of low cloudiness for the indicated directions of flow behind the cold front.

front as the front passed Elkins. Counting the number of 3-millibar isobars to the rear of the front and as far back as the ridge, we are using the hypothesis that we are estimating the duration of the northwesterly flow. Thus, the northwesterly flow at Elkins would diminish as the ridge (shown centered in Kansas in Fig. 1) drifted eastward to West Virginia. Fig. 2 contains all the cases of cold front passages with north-south and northwest-southeast oriented isobars back of the front for the months of January and February from 1946 through 1950.

It was found that if there were showers back of the front over Ohio or Indiana, the duration of the cloudiness was greater than for the cases when there were no showers.

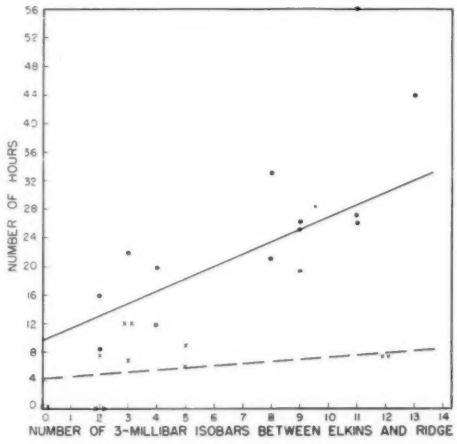


Fig. 4. The relationship of the number of isobars to the duration of low cloudiness for northwesterly flow in March.

The dots on Fig. 2 are the cases when there were showers and the crosses are cases when there were no showers. The solid line was drawn by eye to represent the dots and the broken line for crosses.

The average error of estimate using cases found on the chart is four hours, excluding one unusual case in which six isobars showed a duration of cloudiness of 56 hours. This case was associated with a low that became stationary for several days just to the north of the Great Lakes. The average length of time the cloudiness remained was found to be 22 hours, and using this average as a basis for a forecast, the average error in estimating the time of clearing would have been 10 hours.

Figure 3 contains the cases when the isobars were oriented west-east, northeast-southwest, and east-west. A relationship similar to that shown in Fig. 2 could not be found for these, since, as one might expect, the physical factors present with northwest flow are not acting similarly with flow from other directions. The median reading (circled) was that selected as being indicative of the duration of cloudiness for these cases. It should be noted that here it is much less than for those shown in Fig. 2. This is because air reaching Elkins from these directions has encountered less lifting (actually it descends in east-west cases) and has not had the addition of moisture from the Great Lakes.

Figure 4 was constructed in the same manner as Fig. 2, and is for the month of March. No charts were constructed for November and December, and the present charts are not valid for these months.

A test was made of the charts for January, February, and March, 1945, and 1951, and the average error was eight hours.

SMOKE PALL MOTION PICTURES

At the May meeting of the American Meteorological Society, a long-time member of the Amateur Weathermen of America, H. H. Larkin, Jr., of Buffalo, New York, showed whole-sky motion pictures of the great smoke pall of September 25, 1950. The image of an incandescent lamp filament on every frame of the color film provides a known base for color comparisons.

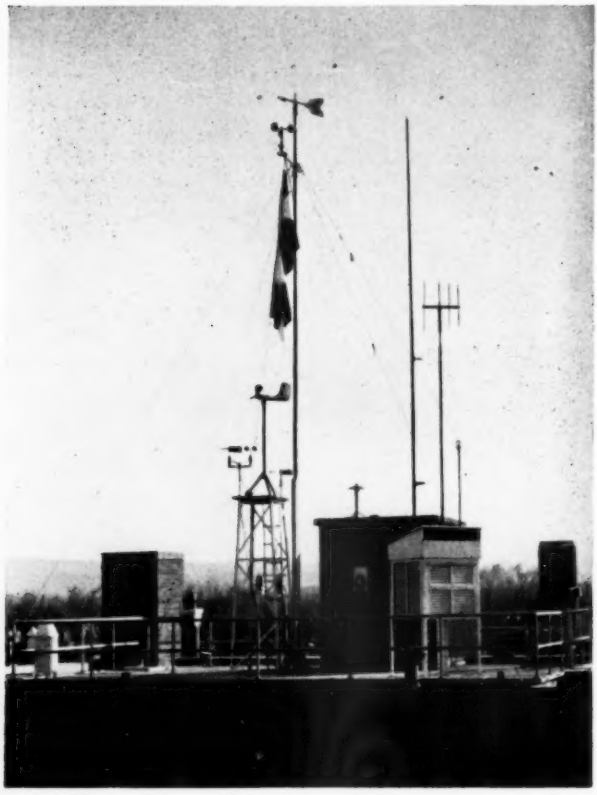
AUGUST MEETINGS AT PENN STATE

THE CAMPUS of The Pennsylvania State College will be the scene of a midsummer gathering of weathermen of many predilections. The American Meteorological Society and the Amateur Weathermen of America will hold sessions at State College, Pennsylvania, in the period from Tuesday, August 7th, through Thursday, August 9th. Situated astride the crest of the Appalachian Mountains, State College has long been known as a summer resort where mild days are followed by cool, refreshing evenings.

Host to this gathering will be the division of meteorology of the School of Mineral Industries. The chief of the division, Dr. Hans Neuberger, technical editor of WEATHERWISE, is well known to professional and amateur weathermen alike. With the assistance of his staff and students, an attractive program of technical sessions and social gatherings has been planned.

The meeting of the Amateur Weathermen of America will take place on the evening of August 7th, at 8:00 p.m. There will be several brief papers on the meteorology and climatology of the central Pennsylvania region. The main talk of the evening will be by Dr. Charles F. Brooks, Blue Hill Meteorological Observatory, on forecasting the weather from cirrus cloud observations. In addition, there will be a forecasting contest and a short movie on clouds.

The program of the American Meteorological Society is now being prepared. It will include sessions on synoptic and dynamic meteorology, agricultural meteorology, and on problems of education in various branches of meteorology. The program will be published early in July, and copies may be re-



The Penn State meteorological observatory on the roof of the School of Mineral Industries. The can on the extreme left is a float-type precipitation recorder. Two standard Weather Bureau rain gages are seen between the tower and the rain recorder (in front of the chimney). On the tower are two sets of wind instruments for student use, a Campbell-Stokes sunshine recorder, and a wheat-rust spore collector mounted on a wind vane (right-hand corner of the tower). The 30-foot pole in the center is topped by the official wind instrument, and carries weather flags. On the left side of the penthouse roof is an Eppley pyrheliometer for recording solar and sky radiation intensity. The FM radio antenna (four arms) is connected with a radio telephone operated in conjunction with the Federal-State Flood Forecasting Service of Pennsylvania. Another short-wave antenna (tall) is to the left of the FM antenna, and a thermostat for air-conditioning purposes to the right. In addition to the instrument shelter, there is a special precipitation trace recorder (extreme right).

quested from the office of the AMS, 3 Joy St., Boston 8, Massachusetts.

The Penn State meteorological observatory and laboratories, as well as the seismograph station, will be open to visitors during the meetings. On every floor of the School of Mineral Industries are displays of gems, precious metals, minerals, and mineral products. There is also a Mineral Industries museum, library, and art gallery. The Penn State campus of 3,000 acres boasts many other points of interest.

Members of the AWA are invited to attend the AMS banquet on the evening of August 8th and to hear the speaker. The dinner price is not expected to exceed $3.50 per person, and may be considerably less. Advance reservations are preferred, although tickets will be available at the meeting.

Those planning to attend these meetings at State College should make their reservations in advance. There will be rooms available in the college dormitories and also in the many hotels and tourist courts in the vicinity. Full reservation details can be obtained by writing to the Division of Meteorology, School of Mineral Industries, State College, Pennsylvania.

THUNDERSTORM SURVEY

A full-scale survey of thunderstorm activity in the region east of the Rocky Mountains will take place during the month of July. Over 10,000 observers will note the occurrence of thunder and lightning in their vicinities and will report directly to the Air Weather Service of the U. S. Air Force. The project is part of the sferics evaluation program of the Air Force, to determine the value of sferics equipment which detects lightning discharges at distances up to 2,000 miles.

Taking part in the survey are the co-operative observers of the U. S. Weather Bureau and certain employees of the American Telephone and Telegraph Company. A pilot survey was conducted during the month of May in the state of Georgia, where the headquarters of the project are located, at Robbins Air Force Base.

THE HAILSTORM PROBLEM

(Continued from page 50)

Plains and the east slope of the Rocky Mountains, according to Mr. Harrison and W. B. Beckwith, of the United Air Lines, in an article on the distribution and forecasting of hail in the western United States, recently published in the *Bulletin* of the American Meteorological Society (April, 1951, page 119). The very comprehensive account points out that not one definite case of hail damage to airplanes in flight has been recorded *west* of the continental divide. The difficulty in forecasting when and where pilots will encounter critical-size hail in flight requires each pilot to exercise good judgment in avoiding damaging hail and severe thunderstorm turbulence.

INSIDE A TEXAS TORNADO

(Continued from page 57)

ing, in some way beyond my knowledge, for the total lack of noise within it.

The very instant the rim of the funnel passed beyond the wreck of the house, long vaporous-appearing streamers, pale blue in color, extended out and upward toward the southeast from each corner of the remaining room. They appeared to be about 20 feet long and six inches wide, and after hanging perfectly stationary for a long moment, were suddenly gone.

The peculiar bluish light was now fading, and was gone abruptly. Instantly it was again dark as night. With the darkness my hearing began to come back. I could hear the excited voices of my family in the small back room, six feet away, and the crunching jars of heavy objects falling around the house. The tornado had passed. The rear edge was doubtless high off the ground and went over without doing any damage. Quickly, real daylight commenced to spread in the wake of the storm, and how good it did look! And how astonishing! I had come to believe, in those few long minutes, that the tornado had struck in the nighttime. It was now about 3:06 p.m.

Luck was with us that day. The only injuries sustained by the family were a severe gash in my boy's arm and a scalp wound on my own head. The rest of the district did not fare so well. The tornado cut a swath through the southern part of the city, killing and wounding upward of a hundred people, and doing property damage of over five million dollars.

Meteorology in California Civil Defense

COURTLAND L. WASHBURN, METEOROLOGIST
RADIOLOGICAL SERVICES, CALIFORNIA OFFICE OF CIVIL DEFENSE

ONE of the principal functions of the Radiological Services in the civil defense program is so to deploy its monitors that in the event of an atomic explosion definite information can be obtained quickly as to the extent and level of contamination. It is also necessary to formulate plans to deal with dust-borne radioactivity subsequent to an attack. Work of this character will be greatly facilitated if weather conditions before, during, and following an attack are known and the fall-out areas are anticipated. Information on the wind patterns will also be necessary in the event of biological or chemical warfare.

In order to provide information along this line, a meteorologist was attached to the staff of the Radiological Services. It is his responsibility to see that complete and continuous meteorological data are made available to the regional co-ordinators in each of the regions and operational areas into which the state is divided. Three of these regions, at San Francisco, Los Angeles, and San Diego, are considered critical targets and will have an organization similar to that existing at the state level, including a meteorological service.

The organization of the meteorological services in the three critical target areas is the primary objective of the meteorologist at the present time. Meteorologists with experience in these areas are hard to find, and it would not be possible for the State Office of Civil Defense to establish meteorological facilities due to the expense involved. It is therefore desirable to obtain the necessary data and have the map analysis done by experts in the U. S. Weather Bureau stations in the areas. Less experienced meteorologists can then be used to staff the regional control centers. It is gratifying to note the enthusiasm with which officials of the Weather Bureau are co-operating.

As an example, we can consider the plans being developed for the San Francisco Bay area, which will be extended to other areas.

The number of weather reporting stations in the region operating on a 24-hour basis is not sufficient to give the complete coverage necessary for a detailed study of the air-flow picture. Therefore, those stations reporting only during the daylight hours will be requested to send in reports every three hours during the entire 24-hour period.

New reporting stations are to be located at firehouses or police stations, where personnel will be available to make the observations and send in the reports on a 24-hour basis. The equipment proposed for each of these stations includes an anemometer, wind vane, indicator cabinet, and sling psychrometer. The meteorological staff attached to the regional control center would train the personnel at the firehouses to observe and report the data and would also maintain the equipment. These auxiliaries would send their weather reports by telephone every three hours to the nearest regular weather reporting station to be put on the local teletype circuit where, along with the reports from the existing stations, they would be available to the Weather Bureau Airport Station in San Francisco. There, meteorologists would draw and analyze a map for the region every three hours.

The regional meteorological staff will work with the personnel at the Weather Bureau Station to try to determine typical weather types for the region, using the three-hourly maps as guides. When these types have been established they will be coded and put on file in the Weather Bureau Airport Station, the Regional Control Center, and the State Office at Sacramento. Thereafter, when the three-hourly map is drawn at the Weather Bureau Station, the meteorologist on duty at the Regional Control Center would be informed by telephone of the type prevailing. Data on the upper winds and any other desired information would be given at the same time.

The region meteorologists would thus have on hand data from which fall-out patterns for the different types of explosions for any of the air-flow types in the region could be estimated. A continuous picture of the weather would also be on hand in case of sudden emergency.

Artificially Induced Fog Engulfs Denver Airport

DURING the early morning hours of February 25, 1951, Stapleton Field, Denver, Colorado, was closed to air traffic by a shallow layer of dense fog while the rest of the surrounding countryside was flooded by the light from a full moon. This condition was artificially induced and, consequently, not expected and not forecast. As a result, there was considerable inconvenience to the airlines. Planes had to land elsewhere to refuel or await the dispersal of the fog: some landed at Buckley Naval Air Station a dozen miles to the southeast of Stapleton Field.

Pilots reported that the narrow band of fog was apparently issuing from the stack at the Rocky Mountain Arsenal. This is a chemical manufacturing and processing plant located about five miles to the northeast of Stapleton Field. At its maximum development the fog bank covered no more than five by eight miles.

Investigation revealed that the principal constituent of the fumes emitted by the stack at that time was gaseous hydrogen chloride, a highly hygroscopic substance. The fog was accompanied by the pungent odor of this gas. The affinity of gaseous hydrogen chloride for water enables it to produce visible water droplets in air that is sufficiently dry that fog would not form in its absence.

Smoke or localized fog from the arsenal stack was first recorded on the 0128M observation. At that time a narrow band of this smoke was being carried southward east of Stapleton Field by a light northerly wind. The wind soon shifted to light easterly, which spread the fume-laden smoke westward across the airport. By 0216M the visibility was reduced to less than a quarter of a mile in dense fog, which remained until after sunrise when heating and variable winds dispersed the fog and fumes.

During the day of February 24, 1951, there was an elongated surface trough with several ill-defined centers just east of the Rockies, from Montana to New Mexico. The weak diffuse cold front that accompanied this trough as it moved eastward passed Denver during the morning. Following the passage of this front there was considerable cloudiness and shower activity over and along the mountains. Denver received a trace of moisture from showers during the afternoon. By 1900M there were only a few stratocumulus clouds remaining in the sky, with scattered to broken cirrus above.

The 2330M synoptic surface chart indicated a weak Lamar low. There was a rather flat high-pressure area over the intermountain plateau. The resulting pressure pattern indicated weak north to south flow over the Denver area. The 2000M 850-mb chart showed a trough east of the mountains in Wyoming and Colorado, this trough indicating a light circulation from the northwest in the Denver area.

Although the showers during the afternoon and nocturnal cooling resulted in high relative humidity at low levels, this synoptic situation is not one that brings either general fog to northeastern Colorado or local fog to the Denver area. There seems to be little doubt that the fog was the result of large quantities of highly hygroscopic hydrogen chloride gas in the area.

Although waste hydrogen chloride was dispensed through the arsenal stack on numerous previous occasions, no previous occurrence of the right combination of humidity and surface winds to produce fog in the Stapleton Field area has been found. About half of the nights when there is no ceiling at Denver a drainage wind from the south-southwest sets in during the night. This carries any smoke from this source away from the airport.

Fog and smoke are quite common in large industrial areas. However, it is believed that dense fog induced in the manner described is rather rare. Plans are under way to revise processing at the arsenal so as to remove the hydrogen chloride from the fumes. Repetition of this situation is not likely at Denver.

FORREST E. HORNING
WBAS, Denver, Colorado

MAY HURRICANE

The hurricane season was inaugurated unusually early this year by a tropical storm that developed in the region of the northern Bahama Islands on Thursday, May 17th. Weathermen had been watching an ominous closed circulation on their upper-air charts for many hours, but it took some time for the circulation to reach the surface of the earth. Winds up to 90 miles an hour were reported from Grand Bahama and Little Abaco islands, and this put the storm in the hurricane class.

A preliminary search of the records indicates that this is the first storm of hurricane proportions to occur during May. In his well-known book on hurricanes, Ivan Tannehill lists five tropical storms in May since 1887, but none was classified as a hurricane.

The recent storm was a slow and erratic traveler. It remained stationary near the Grand Bahama for about 48 hours, moving in a loop that despaired the forecasters at the Miami Hurricane Central. On Saturday, May 19th, the storm center finally took the usual course toward the north and passed about 100 miles east of Cape Hatteras. At that time it had wind speeds up to 100 miles per hour, reported by weather reconnaissance aircraft.

The storm continued northward to the latitude of Washington, D. C., then very slowly toward the east. At 1800 Universal time May 21st it was at 37° north, 73° west. Forty-eight hours later it was half a degree farther north, but at 64° west longitude. It was notable for its failure to speed up as it came northward.

Basic weather facts for forecasters

HOW ABOUT THE WEATHER?

by Robert Moore Fisher

Foreword by Ernest J. Christie, Chief United States Weather Bureau, New York

With simple, easily understandable examples the author explains what makes temperatures rise or drop; what weather changes result from various clouds; what distinguishes high and low pressure areas, and warm fronts, cold fronts, occlusions; and how to read, interpret, and utilize weather maps in order to arrive at your own forecast. Even if you've been your own forecaster on occasion, your ability will be improved by what you read in this authoritative book and by what you learn from following its precepts. With 32 pages of photographs and weather maps, and five line drawings. Index.

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WORKBOOK FOR WEATHER FORECASTING

E. S. Pulk and E. A. Murphy. Prentice-Hall, Inc., New York, 1950. 66 pages plus map series kit. $5.00.

DESPITE the large volume of literature on the subject of meteorology that has been published in this country during the past decade, there has been very little space devoted to the actual problems of the practicing forecaster. Since the appearance of Victor Starr's **Basic Principles of Weather Forecasting** in 1942, there has been no single volume on the subject. Many pamphlets on specific regions and many particularized studies on special phenomena have appeared, but there has been no synthesis of the material.

When one considers the inadequacy of our present knowledge of atmospheric processes and the complexity of forecasting what is not thoroughly understood, it is not surprising that we do not have the practical forecasting manual that all would desire. Forecasting the weather is still largely an art that requires long experience, a disciplined mind, and unfailing mental stamina. The forecaster acquires a vast knowledge of his daily occupation, but often finds it difficult to transmit his knowledge to another. It is axiomatic that the best teacher of meteorology is often the poorest forecaster, and vice versa.

Thus, weathermen will welcome the present volume of Pulk and Murphy. The workbook is intended for use in a school course where current teletype data is unavailable. A student may follow through the various exercises and, in part, duplicate the steps that the professional forecaster takes in preparing his daily prognostication.

The following are the chapter headings. 1. Surface station model and plotting exercise. 2. Upper-air station models and plotting exercise. 3. Airways observation code and exercise. 4. Analysis of weather charts. 5. Weather forecasting. 6. Discussion of synoptic weather chart series. In addition, there is an appendix containing a useful glossary, selected formulas and conversion tables, and suggested textbooks.

A unique feature of the workbook is the inclusion in a pocket at the back of six unanalyzed surface weather maps and three unanalyzed upper-air charts. There is also one complete set of surface and upper-air analyzed charts to serve as a guide to the student.

This workbook fills a long-standing need for forecasting material suitable for the laboratory or classroom in an elementary course in meteorology. Its users, however, should not be only

classroom students. All those who wish to gain a fundamental knowledge of the principles behind modern air mass analysis and polar front forecasting will do well to study the text and follow the exercises outlined in this volume.

D. M. L.

NEW CIRCULAR "N" EDITION

A new edition of the bible of weather observers, **Circular N,** has just been issued. Originally entitled **Instructions for Airways Observers,** the publication is now called **Manual of Surface Observations** (WBAN). Instructions for taking and recording weather observations are set forth in the 124-page manual. It is the standard guide in this field for the Weather Bureau, Air Force, and Navy, as the WBAN designation indicates.

Circular N, sixth edition (revised), is a publication of the Department of Commerce, Weather Bureau, and is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., for the sum of one dollar.

A second volume of **Circular N** is now in preparation. This will be devoted to the installation, care, and reading of the standard instruments employed in the government and military weather services.

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WORKSHOP FOR WEATHERMEN

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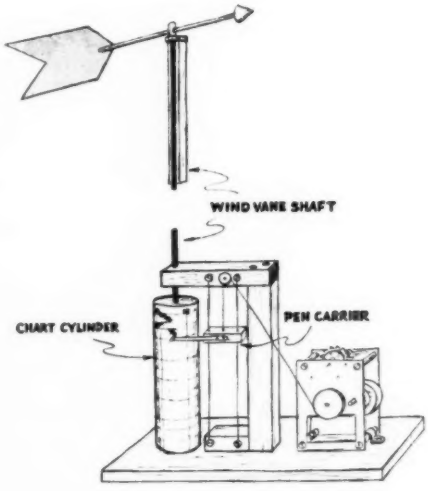
IN THIS TYPE of wind-direction recorder, a shaft, rotated by a wind vane, is fastened to a cylinder. A paper chart, ruled in vertical wind-direction lines and horizontal time lines, is wound around the cylinder and fastened with a rubber band at the top and bottom ends. A pen, controlled by a clock, progresses down the chart; and as the chart rotates (as controlled by the wind vane), wind direction is recorded thereon.

The vane should be at least two feet long. It consists of a tail of fairly large surface, soldered or otherwise fastened to a horizontal shaft. The opposite end of the shaft is counterbalanced by a pointer, molded of lead. (See WEATHERWISE, June, 1948, page 66, "How to Construct a Wind Vane.") The vertical shaft may be made of ordinary ¼" or ⅜" shafting, soldered at the top in a suitable section of brass bushing through which the horizontal wind vane shaft runs. The weight of the vane is supported by a section of strap iron, drilled to take the vertical shaft and fastened to the end of a section of 2" x 2" or 2" x 4" upright mast. This may be mounted on the top of a house or shed, and the wind vane shaft run down through the roof. The recorder must be placed directly under the vane. If you can find one, a roller thrust bearing may be used as the vane bearing. It will, of course, offer less friction to vane orientation in light winds.

The recorder parts are assembled on a wooden base of a size large enough to accommodate the parts you are able to obtain. The chart cylinder may be made of tin or brass, and should have a diameter of about 2" and a height of 8" or 10". These dimensions are not critical, but a cylinder of this size will accommodate a chart made from a sheet of average typewriter page size. The wind vane shaft is soldered to the top and bottom end of the chart cylinder.

Cut the chart paper so it has a height equal to that of the cylinder and is wide enough to allow ¼" overlap as it is put on the cylinder. The chart paper should be ruled with four or eight vertical lines, marked to correspond with wind direction. You may use as many horizontal time lines as you desire, for hourly, half-hourly, or 15-minute spacing. Make a mark on the cylinder to correspond with a particular direction (having it oriented with the wind vane so it shows the proper compass direction). Line the chart paper up so the vertical rulings on it agree with this mark.

You may use an ordinary penpoint, mounted with the hollow side upward on a horizontal pen arm made of thin tin. The pen may be soldered to the arm, or you can use a clip arrangement so the point may be more easily changed. The pen arm is fastened to a small wooden block which slides on two vertical wires that act as guides. These wire guides are supported by an assembly consisting of a horizontal piece of wood mounted on an upright post, as shown in the drawing. This horizontal section of wood is drilled, and the shaft which is connected to the wind vane passes through it. The lower ends of the guide wires are fastened to a wooden block which is mounted on the baseboard. The tin pen arm should be bent so the pen bears lightly against the chart paper.



An old alarm clock or similar clockwork may be used to control the pen movement. A round wooden drum about ½" thick is drilled and thrust on the hour-hand staff of the clock. This drum should have a circumference equal to slightly less than half the height of the chart cylinder. A length of linen thread or fish line is fastened to the pen carrier block, passed over a small pulley wheel on the top horizontal support, wound at least twice around the drum which is rotated by the clock, then fastened to it. As the drum turns, the cord unwinds and allows the pen to travel down the cylinder chart. A 24-hour record of wind direction will thus be made.

Use an equal mixture of writing ink and glycerine in the pen. The top wind vane bearing should be kept well oiled.

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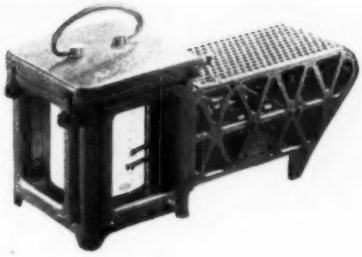

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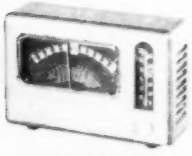

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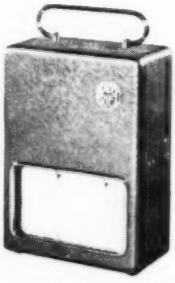

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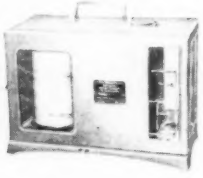

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